do, how nearly theory alone, without any empirical correction, will represent the observations. It is then at once apparent that the residuals cannot be represented by corrections to the epoch of mean longitude, mean motion, and secular acceleration, and any approximation to a mean value of the latter would have different values, according to the mode of using the data. To obtain the best result from the ancient and modern observations combined, it was deemed advisable to assign a minimum probable error of 4" or 5" to each residual for the modern observations. Equations of condition for correction of epoch, mean motion and acceleration are formed, and extend from B.C. 688 to A.D. 1875, or over a period of 2,500 years, and the resulting corrections to Hansen's values for 1800, are, for mean longitude, + 3″·90, mean motion − 19″·03, and for secular acceleration − 3″·36; Hansen's adopted value of the latter being 12″·17, the value which best satisfies the observations discussed by Prof. Newcomb is found to be 8″·8. Though he considers this correction to the tabular acceleration to be clearly indicated, the residuals for the modern observations are yet of such magnitude as to be wholly inadmissible, and therefore the theory in its present state will not represent observations with any value of the secular acceleration, and respecting the cause of the magnitude of these remaining differences, he makes two hypotheses: (1) that they are only apparent deviations caused by inequalities in the earth's axial rotation, (2) that they arise from one or more inequalities of long period in the actual mean motion of the moon. Examining the effect of the first hypothesis, he arrives at the conclusion that if it be correct "the problem of predicting the moon's motion with accuracy through long intervals of time must be regarded as hopeless since it cannot be expected that variations in the earth's axial rotation will conform to any determinable law," and, he adds, "success in tracing the deviations in question to the moon itself and to the theory of gravitation is therefore a consummation to be hoped for." With regard to the second hypothesis, it is seen that the residuals of the equations of condition indicate that the modern observations may be nearly represented by a term having a period of between 250 and 300 years, and hence Prof. Newcomb inquires how closely an empirical correction to Hansen's first term depending upon the action of Venus, the period of which is 273 years, will accord with the modern observations, and he finds a very satisfactory agreement. An additional diminution of 10″ in the secular mean motion of the moon results, which at the present epoch involves a further diminution in the secular acceleration of 0″·5, that the ancient observations may be well represented; thus the acceleration becomes $8''\cdot3 \cdot T^2$. A table is given exhibiting the corrections to Hansen's mean longitude from 1620 to 1900 for every tenth year; in 1880 it is − 11″·2, and in 1900 − 24″·6.

This important volume concludes with some remarks upon the bearing of the value of the moon's secular acceleration deduced from the investigations, of which we have endeavoured to give a general outline here. Prof. Newcomb thinks it is apparent that one of two propositions must be accepted: "Either the recently accepted value of the acceleration and the usual interpretation of the ancient solar eclipses are to be radically altered, the eclipse of − 556 not having been total at Larissa, and that of − 584 not having been total in Asia Minor; or the mean motion of the moon is, in the course of centuries, subjected to changes so wide that it is not possible to assign a definite value to the secular acceleration." It is certain that there will be a difference of opinion upon his main conclusions, and for this he expresses himself fully prepared. If a definite theory of the apparent inequalities of long period in the moon's motion cannot be formed, or if the moon's mean motion is subject to such changes from age to age that no invariable and well-defined value of the secular acceleration can be deduced, then he urges it is not certain that the question whether Hansen's tabular mean longitude during centuries preceding the Christian era does or does not require a considerable negative correction can ever be conclusively settled, since no conclusions can be drawn except from observations made near the period in question, and he advocates the necessity of a further investigation into the eclipses and other data on the two hypotheses, first that Hansen is correct during the period named above, and second, that a correction of − 16′ is required, and suggests that the question should be examined in this manner by some independent authority. If, on the other hand, it is not possible to form a perfect theory of all the inequalities in the moon's mean motion independently of observations, he thinks it will be practicable to arrive at a value of the secular acceleration from the modern observations, reliable within 0″·5.

ROSCOE AND SCHORLEMMER'S CHEMISTRY

A Treatise on Chemistry. By H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S., Professors of Chemistry in Owens College, Manchester. Vols. i. and ii. (Macmillan and Co.)

THIS work is a most valuable contribution to the literature of chemistry. Its aim, as stated in the Preface, is to place before the reader a fairly complete, and yet a clear and succinct statement of the facts of modern chemistry, whilst at the same time entering so far into a discussion of chemical theory as the size of the work and the present transition state of the science permit, special attention being also paid to the accurate description of the more important processes in technical chemistry, and to the careful representation of the most approved forms of apparatus employed.

The manner in which this design has been carried out is such as might have been expected from the high reputation of the authors. The work commences with a very interesting historical introduction, in which the progress of chemistry is traced from the early times, in which it was merely an art subservient to alchemy, medicine, and a few branches of manufacture, to the time when, by the gradual accumulation of observations, and the discussion of them by men of philosophic mind, it rose to the rank of a science. A clear and impartial discussion is given of the relative merits of the various workers by whose labours the system of chemical philosophy now accepted was developed, showing how the phlogistic theory of Becher and Stahl first established a common point of view from which all chemical changes could be regarded,

and enabled chemists to introduce something like a system by which analogous phenomena could be classified and referred to a common cause; further, how the experiments of Black, Cavendish, and Lavoisier first showed the importance of attending, in the study of chemical changes, to the alteration in weight of the substances concerned; and how Lavoisier was ultimately led to the true theory of chemical combination, which regards it as consisting simply in the addition of one element to another, the weight of the product being exactly equal to the sum of the weights of the combining bodies.

Next follows a sketch of the labours of Bergmann, Richter, Cavendish, and others, which led up to the establishment by Dalton of the great doctrine of combination in multiple proportions, on which he founded the "atomic theory." The early experiments of Dalton are briefly described; his table of the relative weights of the atoms of certain elementary and compound bodies is given; and the Introduction ends with an account of the manner in which the exact values of the atomic weights were determined by Thomas Thomson, Wollaston, and more especially by Berzelius; of the discovery of the compound nature of the alkalis by Davy, and of a number of new elements by various chemists; and lastly, of the development of Organic Chemistry and its true relations to the chemistry of inorganic bodies; and the final establishment—chiefly by the researches of Liebig—of the fact that the science of Physiology consists simply in the physics and chemistry of the living body.

The Historical Introduction is followed by a chapter on the General Principles of Chemical Science, in which the methods by which the laws of chemical combination have been established are more fully described, especially that by which Lavoisier demonstrated the nature of combustion and the indestructibility of matter. This part of the subject is well illustrated by diagrams of the apparatus used in these important investigations. A list of the elements with their combining weights is then given, and a table exhibiting the arrangement of the elements in groups, chiefly, but not entirely, according to their combining capacity or quantivalence. Next follows a section on the laws of chemical combination, the methods of analysis and synthesis, the manner in which the law of equivalents and the law of multiple proportions were established, and the explanation of these laws by Dalton's atomic theory. This theory is adopted by the authors as the basis of all their explanations of chemical phenomena, and in this we think they are right: for without insisting on this theory as a matter of absolute certainty, we cannot but regard it as the only theory yet proposed which gives any rational and connected view of the laws of chemical action as established by experiment. There are, indeed, chemists of great eminence, who do not admit it, but hold out expectations of much more satisfactory explanations founded on dynamical views of chemical action. But these views have not yet been sufficiently developed to form a connected theory, and meanwhile we must make what we can of the theory of atoms, which, after all, is not necessarily inconsistent with any dynamical laws, or in other words, with any relations of matter to heat and electricity, that future experiment and observation may develop. There are, indeed, some philosophers who would have us believe in motion without matter, or in other words, in the movement of nothing at all; but this is high transcendental ground, on which we must humbly confess our inability to tread.

The consideration of the volume-relations of gases in combination, as established by Gay-Lussac, leads to the statement of Avogadro's law, according to which *equal volumes of all gases contain the same number of molecules.* This the authors rightly put forward as a hypothesis, the truth of which—like that of the law of gravitation—must be established by its accordance with the whole range of observed phenomena: for as such it must be received by the ordinary student, who is scarcely prepared to understand the manner in which it may be shown to follow as a necessary consequence of the kinetic theory of gases. An exposition is then given of the physical properties of gases, the continuity of the liquid and gaseous states, as demonstrated by Andrews, also a sketch of the kinetic theory of gases; and the chapter concludes with an explanation of the principles of Chemical Nomenclature and Notation.

The remainder of vol. i. treats of the Non-metallic elements. The preparation and properties of these bodies and of their compounds with one another, together with their industrial applications, are carefully described, and excellent figures are given of the apparatus employed for investigation and lecture illustration, also of manufacturing "plant." Especially worthy of notice are the illustrations connected with the manufacture of bleaching powder, sulphuric acid, and coal-gas. The volume concludes with a chapter on Crystallography, copiously illustrated with diagrams. The notation used is that of Naumann, which, for descriptive purposes, is perhaps the clearest and most graphic yet devised.

Vol. ii., part 1 is devoted to the general properties and classification of the Metals, and to the special description of those belonging to seven out of the twelve groups in which they are arranged by the authors. In this part of the work we find the same clearness and accuracy of description and explanation which are conspicuous in the first volume, both in the purely scientific portions and in those which relate to industrial applications. Excellent descriptions and figures are given of the manufacture of alkali and of glass, and of the metallurgy of zinc, copper, lead, silver, and mercury.

The book is well printed, and remarkably free from typographical errors. The few that we have noticed are not likely to mislead, and it is therefore not worth while to specify them, with the exception, perhaps, of one, occurring on p. 38 of vol. i., where it is said that the specific heats of the several elements are "universally" (instead of "inversely") proportional to their atomic weights.

The work, when finished, will afford the most complete systematic exposition of the existing state of chemical science that has yet appeared in the English language; and chemists will look forward with pleasure to the appearance of the second part of vol. ii., which will contain a description of the Iron manufacture, and to that of vol. iii., which will be devoted to the ever-growing subject of ORGANIC CHEMISTRY.